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HEALTH AND FEEDING MANAGEMENT STRATEGIES FOR NEWLY WEANED CALVES

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Health and Feeding Management Strategies for Newly Weaned Calves

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Final Report

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In Cooperation with

Pound-Maker Agventures Ltd. of Lanigan, Sk

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Executive Summary:

Producers interested in backgrounding and or finishing are faced with the fact that if they are not low cost, efficient producers they will not survive in the cattle feeding industry. Feed accounts for 60% or more of non-animal costs. Animal health and death losses account for another 15%. Many feedlot diseases and poor performing cattle trace their origins to the first 21 days in the feedlot. Cattle that do not eat well during the first 3 weeks are subject to disease problems and cattle that get sick often never catch up to their healthy pen-mates. Some feedlot operators and animal scientists believe that cattle can be trained to eat early in the feeding program by limiting the amount of feed placed in the bunk!

Limit feeding programs have been used successfully in the United States to reduce feeding costs through improved efficiency of gain and reduced health problems. Little information is available on limit feeding programs under western Canadian conditions, particularly how they impact health, animal behavior, eating activity and thus performance and cost of gain. This project will attempt to optimize the performance of weaned calves in backgrounding or finishing lots by developing integrated animal health and feeding management protocols.

In order to meet these objectives, the following studies were carried out:

Study 1: The Effects of Feeding Program and Pen Density on Backgrounding Performance of Cattle Fed in Western Canada

Study 2: A Comparison of Antimicrobial Metaphylaxis Methods: Oral Chlortetracycline versus Injectable Oxytetracycline in Feedlot Calves on Arrival

Study 3: The Effects of Limit Feeding Finishing Cattle in Western Canada

Study 4: Limit-Feeding High Energy Barley-Based Diets to Backgrounding and Finishing Cattle in Western Canada

Study 5: The Effects of Limit Feeding High Energy Finishing Diets During the Backgrounding Phase on Finishing Performance.

Study 6: The Effects of Limit Feeding High Energy Finishing Diets During the Backgrounding Phase – Repeatability of Results (Trial 5).

Study 7: Effects of Limit Feeding A High Energy Finishing Diet on Manure Production and Management Costs.

The feeding trials were run in cooperation with Pound-Maker Agventures of Lanigan, Sasakatchewan who supplied cattle for the backgrounding studies. Two basic approaches were taken to develop limit feeding programs for cattle fed under western Canadian conditions. The first involved limit feeding backgrounding or finishing diets at a pre-determined level relative to full fed cattle (Trials 1 and 3). The second involved programmed or limit feeding a high grain finishing diet to achieve a pre-set level of daily gain. The practical application of the results differed markedly between the two approaches. In trial 1 and 3 limit feeding backgrounding or finishing diets to levels ranging from 87 to 95 % of full fed cattle resulted in a corresponding drop in average daily gain that

matched almost exactly the reduction in feed intake. As a result there was no improvement in feed efficiency and with finishing cattle the animals required a considerably longer period of time on feed to achieve the same gains. Differences between the success of such programs observed between western Canada and the United States were attributed to environmental effects and the fact that under western Canadian conditions limit feeding in such a manner reduces energy intake for maintenance requirements to keep warm and as a result animal performance suffers.

The second approach to limit feeding shows considerably more promise. That is the practice of program feeding a high energy finishing diet to specific rates of gain. In trial 4 of this series we examined the effects of limit feeding a high-energy barley-based finishing diet to backgrounding cattle targeted for 1.3 kg per day gain. The results indicated that cattle limit fed the high energy diet during the backgrounding period exhibited a similar daily gain (1.36 vs. 1.33 kg / day) to cattle fed a forage based diet ad libitum, however dry matter intake was reduced by 15%. This resulted in an improvement of 16.5 % in feed efficiency, which translated in a reduced cost of gain of $0.08 per kg of gain or $8.05 per head. Further work was under taken to determine the repeatability of these results. In trials 5 and 6, which were conducted in a similar fashion, improvements in feed efficiency ranged from 17 to 22% with feed cost savings calculated under the actual pricing conditions of the study ranging from $5 to $10 per head. In a 3000 head backgrounding lot this would translate to a savings of $15,000 to $30,000 per turn of cattle or $30,000 to $60,000 per 6000 head fed per year. It should be noted that the economic benefits of limit feeding a high grain diet will be dependant on the relative price of grain to forage sources. When grain is cheap, feed savings in excess of what was found in this trial can be expected. As forages become cheaper, then savings are reduced.

The final phase of this work focused on determining the impact that limit feeding a high grain diet to backgrounding cattle has on manure production. It was found that limit fed cattle had a 32% reduction in fecal dry matter output relative to full fed cattle fed to gain the same on a high forage diet. When these numbers are extrapolated to commercial pen cleaning costs, a 45 % reduction in manure removal costs is achieved with limit feeding.

The results of this study are of significant interest to the feeding industry in Saskatchewan and western Canada. Not only is the cost of gain reduced but limit feeding a high energy diet that has increased nutrient availability will markedly reduce manure output by the animal. Since pen cleaning is a major cost for feedlots in Saskatchewan, limit-feeding programs will significantly reduce operating costs for cattle feeders in this province.

Industry interest in the results of this project is evident when one looks at the requests for information on the results. The work was presented to the Bovine Practitioners in Alberta by J. Campbell in 2000 and to the Western Nutrition Conference in Saskatoon in September of 2001 by J. McKinnon. It was also presented to Saskatchewan and Alberta feedlot veterinarians hosted by Elanco / Provel in September of 2002. An article on the results was recently published in the Saskatchewan Cattlemen's magazine – The Cattle Feeder (Nov 2002) and finally the results were presented to the Quebec Cattle Feeders Association in November of 2002. The results have also been implemented on a commercial scale at several Saskatchewan and Alberta feedlots.

This work was conducted in cooperation with industry partners. In particular, the authors would like to express their appreciation to Mr. Brad Wildeman of Pound-Maker Agventures of Lanigan for his cooperation with the research and for providing access to cattle for use in the backgrounding trials. Appreciation is also expressed to Jean Pogu of Duck Lake, Sk., for his interest in and helpful insights into limit feeding programs.

1. Introduction:

Research at the University of Saskatchewan has shown that modest increases in the activity of the Saskatchewan beef industry could generate an additional billion dollars in revenue and expenses (McNinch, Brown, McKinnon 1996). Add this to the one billion $ or so currently generated by the industry and one can quickly see the vital role this industry can play in the development of the rural economy! Producers interested in backgrounding and or finishing are however faced with the fact that if they are not low cost, efficient producers they will not survive in this industry. Feed accounts for 60% or more of non-animal costs. Animal health and death losses account for another 15%. Many feedlot diseases and poor performing cattle trace their origins to the first 21 days in the feedlot. Cattle that do not eat well during the first 3 weeks are subject to disease problems and cattle that get sick often never catch up to their healthy pen-mates.

Some feedlot operators and animal scientists believe that cattle can be trained to eat early in the feeding program by limiting the amount of feed placed in the bunk! Limit feeding programs have been used successfully in the United States to reduce feeding costs through improved efficiency of gain. In essence, the cattle gain the same, while feed intake is reduced 5 to 10%. Acidosis related problems are also reduced. A 10% improvement in the efficiency of Saskatchewan feedlots would make them more competitive with their Alberta and American counterparts. However, under Saskatchewan winter conditions, limit feeding may not work due to cold stress and the fact that we tend to place a higher percentage of freshly weaned calves on feed than feedlots in the United States. These cattle are under more stress and tend to get shipping fever easier and to a greater degree than yearlings. Little information is available on limit feeding programs under western Canadian conditions, particularly how they impact health, animal behavior, eating activity and thus performance and cost of gain. This project will attempt to optimize the performance of weaned calves in backgrounding or finishing lots by developing integrated animal health and feeding management protocols.

2. Work Carried Out:

The following studies were carried out to meet the objectives of this project:

Study 1: The Effects of Feeding Program and Pen Density on Backgrounding Performance of Cattle Fed in Western Canada

Study 2: A Comparison of Antimicrobial Metaphylaxis Methods: Oral Chlortetracycline versus Injectable Oxytetracycline in Feedlot Calves on Arrival

Study 3: The Effects of Limit Feeding Finishing Cattle in Western Canada

Study 4: Limit-Feeding High Energy Barley-Based Diets to Backgrounding and Finishing Cattle in Western Canada

Study 5: The Effects of Limit Feeding High Energy Finishing Diets During the

Backgrounding Phase on Finishing Performance.

Study 6: The Effects of Limit Feeding High Energy Finishing Diets During the Backgrounding Phase – Repeatability of Results (Trial 5).

Study 7: Effects of Limit Feeding A High Energy Finishing Diet on Manure Production and Management Costs.

Study 1: The Effects of Feeding Program and Pen Density on Backgrounding Performance of Cattle Fed in Western Canada

Rational:

Feedlots are under increasing pressure to maximize the use of pen space and feeding equipment. This can and is being accomplished by maximizing the number of head days over the course of a year and by increasing the number of cattle housed within the pen. Pen density can be adversely effected by such factors as wet weather and muddy pen conditions, which keep cattle in closer contact and if too severe can disrupt key performance indicators such as gains, conversions and possibly health.

The possible adverse effects of high pen densities on cattle can be compounded by limit feeding programs that many feedlots are considering or have implemented. Limit feeding programs are designed too minimize digestive disturbances and off-feed problems by reducing the day-to-day variation in pen intakes. Cattle can be limit fed by feeding 85 to 95% of ad libitum intake or by practicing a slick-bunk program. However in the case of high pen densities this can lead to competition amongst cattle for space at the feedbunk with the result that less aggressive cattle may not get enough to eat. This should lead to greater variation in average daily gains within the pen and as a result poorer overall pen performance. If cattle are stressed early in the feeding period, it can also lead to increased health problems during the first 28 days of the feeding program. High pen densities can be simulated by restricted feed bunk space.

General recommendations exist for pen square footage and bunk space for growing and finishing cattle. However, little information exists on the impact of limited feed bunk space on the performance of cattle particularly when limited bunk space is combined with limit feeding.

Objective:

To study the interaction of feed bunk space and limit feeding programs on performance (i.e. growth, pen intakes and efficiency) and health (treatment rates, death loss, etc.) of exotic cross steers fed to gain 1.0 to 1.1 kgs per day in a 70-day backgrounding period.

Protocol:

Two trials were conducted in conjunction with Pound-Maker Agventures of Lanigan, Sk. In each trial 384 steer calves were assigned to 12 pens (21.4 x 24.4 m with 18.3 m feedbunks) in the Beef Cattle Research Unit at the University of Saskatchewan. The cattle were owned by Pound-Maker Agventures and backgrounded at the University of Saskatchewan for the duration of the trial. The results presented in this report pertain only to the backgrounding period.

Treatments included the industry standard for feed bunk space (25.4 (10") cm of bunk space per head) and a reduced feeding area (15.4 (6") cm bunk space per head). Feeding program included full feed (fed to leave approximately 10%) and limit fed at 87% of ad libitum intake. The cattle were fed a diet that averaged 54% barley silage, 28% barley-based concentrate and 18% hay/straw mix (as fed basis). Cattle were targeted for 1.0 to 1.1 kgs gain per head per day. The cattle were fed 3 times a day with ad libitum fed cattle fed a set amount at 0830 and 1030 and the remainder of the total daily allotment fed at 1300h. Limit fed cattle were fed 87% of the 7-day average intake of the ad libitum fed cattle from the previous week in equal portions at 0830, 1030 and 1300h.

Each animal was weighed twice at the start of test and once every two weeks prior to the end of test at which point they were again weighed on two consecutive days. The animal health and receiving program was carried out under the direction of Drs. Jansen and Campbell.

Design:

Each trial was analyzed as a 2x2 factorial with 3 pens of cattle per treatment combination. The pen unit was used for all calculations. Subsequently the data was combined across the two years and analyzed over both years of the trial with 6 pens per treatment.

Results:

The results from Trials 1 and 2 and combined over both trials are presented in Table 1. For the purposes of this discussion, only the combined results will be discussed. As expected from the design of the trial, dry matter intake was influenced by feeding program with lower intakes found in calves that were restricted to 87% of the intake of ad libitum fed calves. Dry matter intake was also higher in calves with limited bunk space. A feeding program by bunk space interaction indicated that this effect of bunk space was only seen with ad libitum fed calves.

Limit fed calves only gained 86% ($P<0.05$) of the full fed controls (1.05 vs. 1.22 kg per day). This was consistent over both years of the study. There was no effect of feed bunk length on gain in either year of the study. When full fed, cattle tended to be more efficient ($P<0.05$) feed converters (7.3 vs. 7 kgs feed/kg gain) when given greater room at the bunk. No effect of bunk length was apparent with limit fed cattle.

The initial results of our work indicates that limit feeding may not be as effective in western Canada as observed in the United States. In this trial, cattle fed 87% of ad libitum fed cattle gained 86% of their contemporaries and thus were no more efficient at converting feed than their full fed counterparts. This is in contrast to American studies where limit fed cattle tended to gain the same as the full fed cattle and since they were limit fed by 10 to 15% were more efficient in converting

feed to gain. Differences in the performance of cattle limit fed in western Canada and those fed in the mid-west of the United States may well be due to climatic differences. Colder winters would increase the maintenance energy needs of cattle fed in western Canada and thus would contribute to reduce gains. It is interesting to note that in trial 2, the limit and full fed cattle were finished in separate pens at Pound-Maker Agventures in Lanigan, Sk. During the finishing period, cattle limit fed during the backgrounding period gained faster (1.61 vs. 1.71 kgs per day) were more efficient (6.3 vs. 6.7 kgs feed per kg of gain) and resulted in $36 per head more profit than cattle which had been full fed during the backgrounding period. As discussed, the finishing phase was conducted at a commercial feedlot and thus it was not possible to conduct statistical analysis on this data. It is evident however that limit fed cattle exhibited compensatory gain during the finishing period and this resulted in superior finishing performance that translated into increased feeding profits. Further work was planned to explore these results in more detail.

Table 2 shows the morbidity and mortality rate for bovine respiratory disease and the relapse rate. There was no effect of feeding program or bunk length on the health of the cattle.

Table 1. Effects of feed program and bunk length on performance of cattle.

	Ad libitum Intake	Restricted Intake[1]	SEM	Short Bunk[2]	Long Bunk[3]	SEM
Dry Matter Intake (kg / day)						
Year 1	8.92	7.78	0.03	8.46	8.23	0.03
Year 2	8.26	7.19	0.08	7.81	7.63	0.08
Combined	8.69	7.56	0.04	8.25	8.00	0.04
Average daily gain (kg / day)						
Year 1	1.33	1.16	0.02	1.28	1.22	0.02
Year 2	1.11	0.93	0.01	1.02	1.02	0.01
Combined	1.22	1.05	0.01	1.15	1.12	0.01
Feed Conversion (kg feed / kg gain)						
Year 1	6.69	6.72	0.10	6.64	6.77	0.10
Year 2	7.45	7.71	0.12	7.66	7.49	0.12
Combined	7.16	7.30	0.08	7.26	7.20	0.08

[1] Restricted to 87% of ad libitum intake;
[2] Short bunk = 15.4 cm (6"); [3] Long bunk = 25.4 cm (10").

Table 2. Effects of ad-libitum vs. restricted feeding at one of two bunk lengths on health parameters of cross bred calves (Trial 1)*

	Feed Level		Bunk length	
	Ad-Libitum	Restricted	15.4 cm	25.4 cm
BRD Morbidity Rate	27.1%	24.5%	21.4%	30.2%
BRD Relapse Rate	40.2%	37.5%	30.2%	47.4%
Mortality Rate	1.04%	2.08%	1.56%	1.56%

* All values are based on pen averages
** There were no significant differences observed between treatment groups

Study 2: **A Comparison of Antimicrobial Metaphylaxis Methods: Oral Chlortetracycline versus Injectable Oxytetracycline in Feedlot Calves on Arrival**

Introduction:

Giving weaned calves antibiotics on arrival to the feedlot has proven to be a cost effective management procedure in the prevention of bovine respiratory disease.. The term "metaphylaxis" has been used for this procedure which may actually be providing treatment to early cases of bovine respiratory disease as well as preventing new cases from occurring by halting the explosive growth of Pasteurella hemolytica in the nasopharynx. The objective of this experiment was to compare oral chlortetracycline versus injectable oxytetracycline as methods of providing metaphylactic antibiotics to weaned calves on arrival to the feedlot

Materials and Methods

The trial was conducted at the University of Saskatchewan research feedlot. Animals were housed in open-air, dirt-floor pens arranged side by side with central feed alleys and 20% porosity wood-fence windbreaks. Each pen is designed to hold approximately 30 to 40 animals. The animals utilized in this study were 384 mixed breed, auction-market derived, weaned steer calves. The average individual animal weight of animals allocated to the study was 295 kg . Upon arrival at the feedlot animals were weighed, ear tagged, and implanted with a hormone growth implant (Synovex-S, Ayerst Canada). Individual animals were randomly assigned to a pen of 32 animals. Each pen of cattle was randomly assigned to one of two experimental groups as follows: Injectable long acting oxytetracycline administered subcutaneously at a dose of 20 mg/kg (**Inject**); or chlortetracycline premix (Terramycin-50, Pfizer Animal Health) in the feed for the first four days after arrival(**Feed**). The premix was added at a level so that calves eating 1.7% of their weight in dry matter intake would obtain approximately 1.8 grams of chlortetracycline/head/day. After four days, the animals were re-randomized into pens, which were assigned four treatments, which consisted of combinations of ad libitum vs. restricted feeding, and short vs. long bunks. Equal numbers of calves on each antibiotic treatment were randomized into each of the pen-level treatments.

Standard mixed complete feedlot diets, formulated to meet or exceed the nutritional requirements of feedlot cattle (Nutrient Requirements of Beef Cattle, National Research Council, 1984), were offered to the cattle. The diets were blended by combining rolled barley, barley silage, grass hay, tallow, and supplement.

Animals were observed twice daily by experienced feedlot personnel. Those cattle that appeared depressed, gaunt, off-feed, or that were significantly different from their pen-mates were presented to the feedlot veterinarians. Those calves with rectal temperatures greater than 40.5 degrees Celsius with no other signs attributable to other organ systems were considered cases of undifferentiated bovine respiratory disease. These calves were treated with tilmicosin subcutaneously at the label dosage of 10 mg/kg. Those calves that were presented to the feedlot veterinarian that had been previously treated with antibiotics with a rectal temperature greater than 40.5 degrees Celsius were considered relapses and treated with trimethoprim-sulfa intramuscularly for 3 days at the label dosage of 2.6 mg/kg. All calves that died were necropsied at the WCVM Diagnostic Laboratory.

Results:

The average intake/day (as fed) for the first four days after arrival based on pen averages was 5.26 kgs/day in the calves in the "Feed" treatment group and 5.67 kgs/day for the calves for the "Inject" treatment group. These means were not significantly different when compared using a two-sample t-test (P=0.10). This level of intake for the calves receiving chlortetracycline in the feed provided on average 1.33 g of chlortetracycline per head per day to this treatment group. The average weight gain for the first four days after arrival was 6.3 kg for the "Feed" treatment group and 8.3 kg for the "Inject" treatment group based on pen averages. These means were not significantly different when compared using the two-sample t-test (P=0.32).

In the group that received prophylactic injectable antibiotics, 24.0% of the calves (46/192) were treated for BRD. In the group that received antibiotics in the feed for four days, 27.6% of the calves (53/192) were treated for BRD. These proportions were not significantly different when compared using the Chi-square test for heterogeneity (P=0.41). The calves that received injectable oxytetracycline had a 34.8% relapse rate (16/46 calves) after their 1st treatment, while the calves that received antibiotics in the feed had a 41.5% relapse rate (22/53 calves) after their 1st treatment. These proportions were not significantly different when compared using the Chi-square test for heterogeneity (p=0.47). Both treatment groups had 3/192 calves die (1.56%). The average number of days on feed at first treatment was 10.4 days for the calves that received antibiotics in the feed, and 14.3 days for the calves that received injectable antibiotics on arrival. These means were significantly different when compared using the two-sample t-test (p=0.002).

Conclusions:

There were no significant differences between the calves given injectable oxytetracycline on arrival and the calves fed chlortetracycline in the feed for four days after arrival in most of the health parameters such as morbidity and mortality. The calves that received antibiotics in the feed tended on average to be treated a little earlier in the feeding period than the calves that received injectable antibiotics at arrival. There was also a trend towards lower intakes in the first four days and lower weight gains in the calves that received antibiotics in the feed, however, these trends were not statistically significant. The difficulties in formulating the receiving ration so that each calf received the desired quantity of chlortetracycline in the feed were highlighted in this study. It is difficult to estimate intakes for the first few days after arrival, and because of this it would seem logistically simpler to use injectable antibiotics for metaphylaxis rather than antibiotics in the feed.

Table 3: Effects of Oral Chlortetracycline fed for four days after arrival versus injectable long-acting oxytetracycline on arrival on health parameters and feed intake of crossbred calves

	Oral Chlortetracycline (1.33 g/head/day)	Injectable Oxytetracycline (20 mg/kg)
Intake/day (as fed) for 1st four days on feed (kg)	5.27 kg	5.68 kg
Average Weight Gain for 1st four days on feed (kg)	6.3 kg	8.3 kg
BRD Treatment Rate	24.0%	27.6%
1st Relapse Rate	34.8%	41.5%
Mortality Rate	1.56%	1.56%
Average number of days on feed at first treatment*	10.4 days	14.6 days

* Means are significantly different ($P<0.05$)

Study 3: Limit Feeding Programs for Finishing Cattle Fed in Western Canada

Rational:

Limit feeding programs have been used successfully in the United States to reduce feeding costs through improved efficiency of gain. In essence, the cattle gain the same, while feed intake is reduced 5 to 10%. Acidosis related problems are also reduced. A 10% improvement in the efficiency of Saskatchewan feedlots would make them more competitive with their Alberta and American counterparts. However, under Saskatchewan winter conditions, limit feeding may not work due to cold stress and the fact that we tend to place a higher percentage of freshly weaned calves on feed than feedlots in the United States. These cattle are under more stress and tend to get shipping fever easier and to a greater degree than yearlings. Little information is available on limit feeding programs under western Canadian conditions, particularly how they impact health, animal behavior, eating activity and thus performance and cost of gain.

Objective:

To study the effects of limit feeding finishing cattle fed under western Canadian feeding conditions on performance and carcass quality.

Protocol:

Two hundred and eighty-eight crossbred steers weighing 315 kg were assigned to 24 pens at the Beef Cattle Research Station at the University of Saskatchewan in Saskatoon. Each pen was assigned to one of 4 intake levels of a high-energy barley-based finishing diet:

1. ad libitum intake throughout the trial;
2. 95% of ad libitum intake throughout the trial;
3. 90% of ad libitum intake to the midpoint of the trial followed by ad libitum intake through slaughter;
4. 90% of ad libitum intake throughout the trial.

Limiting feeding was accomplished by restricting intake relative to the average intake of the ad libitum fed pens.

The cattle were fed to finish and slaughtered at XL Beef in Moose Jaw, Sk. Data collection included biweekly pen intakes and individual average daily gains as well as ultrasound measurements of backfat level and ribeye area at the start, mid-point and at the end of the trial. Each animal was weighed twice at the start and end of test and once every 2 weeks throughout the trial. At slaughter, each carcass was measured by Canadian Beef Grading Agency graders for weight, average fat thickness, ribeye area, yield grade and marbling score.

Design:

The trial was analyzed as a completely randomized design with 6 pens per treatment. The pen served as the unit of comparison.

Results and Discussion:

The results from this trial are presented in Tables 4 through 7 with diet composition and analysis given in Tables 4 and 5. The digestible energy content of the diet averaged 3.4 Mcal per kg of DM or 78% TDN. In the total mixed ration the ratio of barley gain and supplement to forage (barley silage/hay) averaged 90:10, respectively (DM basis). Crude protein content averaged 13.4 % and was within the requirements of the NRC (1996) requirements for cattle of this type and weight.

Feedlot performance of cattle fed the four treatments is given in Table 6. Start of test weights averaged 315 kg with cattle carrying between 2 and 2.5 mm of backfat. Through the midpoint of the trial (day 98), the full fed cattle consumed 8.41 kg of DM per day. The limit fed cattle consumed 4 and 8 % less dry matter relative to the full fed treatment. Average daily gain for the cattle fed at 95% of ad libitum intake was 1.61 kg per day, or 8.5% less than the ad libidum fed cattle (1.76 kg/day). Similarly, the 2 groups of cattle fed at 90% of ad libitum intake gained 10 and 8.5% less than the control cattle. Feed to gain ratios while not statistically different, favored the ad libidum fed cattle at day 98.

When performance was considered over the course of the trial similar results were noted. Dry matter intake averaged 9.62 kg per day. This was 4, and 9.3 % higher than treatments 2 and 4 which were limit fed throughout the entire trial. Cattle than were limit fed at 90% up to the mid-point of the trial and then full fed until finish actually consumed the most feed over the entire trial (Table 6). The cattle than were limit fed for the entire trial exhibited reduced daily gains relative to treatments 1 and 3 which were full fed for the entire feeding period or for the last 90 days of finishing, respectively. Limit feeding increased the days on feed by an average of 23 days. Overall feed to gain ratios were not statistically different between treatments, however numerically they were superior for the full fed cattle from the beginning of the trial (Table 6).

The cattle were targeted for slaughter when they were carrying approximately 8 mm of backfat as measured by ultrasound. No differences between treatments in carcass composition were found (Table 7). This is to be expected when cattle are killed at a constant backfat end point. However, as indicated previously it took on average 23 days longer for limit fed cattle to reach a similar carcass composition relative to full fed cattle.

The results of this trial showed that relative to full fed cattle, limit feeding from 315 kg through slaughter of a finishing diet did not result in any beneficial effect on performance or carcass composition. Performance was actually impaired since limit fed cattle under the treatments imposed in this study resulted in an additional 23 days on feed to get to the same carcass end-point as the full fed steers.

Table 4. Average ingredient make-up of ration fed to all steers

Complete mixed ration average composition (g kg^{-1})	
Barley Silage	92.6
Barley Grain	831.9
Finishing Concentrate Pellet	58.9
Canola Pellet	13.3
Hay	3.3
Finishing concentrate pellet ingredients (g kg^{-1})	
Ground barley	390.0
Molasses	325.5
Canola meal	220.0
Limestone	150.0
Lab supplement[y]	70.0
Rumensin premix[x]	55.0
Trace mineral selenium	40.0
Tallow	32.5
Canola pellet ingredients (g kg^{-1})	
Ground barley	35.0
Molasses	32.5
Canola meal	670.0
Limestone	80.0
Lab supplement[y]	70.0
Rumensin premix[x]	40.0
Trace mineral selenium	40.0
Tallow	32.5

[x] contains 3% rumensin

[y] contains 400g of Vitamin A and 80g of Vitamin D_3 both at concentrations of 500,000 IU/g.

Table 5. Average chemical composition of feed ingredients used during the trial.

	Protein	SD[z]	Ash	SD	ADF	SD	NDF	SD
Barley Silage[A]	12.63	0.58	9.36	0.45	34.42	1.70	51.67	1.95
Barley Grain[B]	13.14	0.78	2.68	0.16	6.26	0.29	20.48	0.74
Finishing Conc. Pellet[C]	15.93	0.74	18.37	0.96	8.46	0.64	14.01	0.94
Canola Pellet[D]	27.67	0.64	15.85	0.73	12.88	0.47	18.40	1.32
Hay[E]	9.51	0.31	5.60	0.27	43.64	0.41	70.01	1.23
Total Mixed Ration	13.44		4.41		9.21		23.14	

[z] Standard deviation among samples

[A] Barley silage contained 30.3% dry matter

[B] Barley grain contained 87.6% dry matter

[C] Finishing concentrate pellets contained 89.2% dry matter

[D] Canola pellets contained 89.8% dry matter

[E] Hay contained 84.5% dry matter

Table 6. Effects of restricted feeding on growth traits of feedlot steers

	Diet				
	1[v]	2[w]	3[x]	4[y]	SEM[z]
Start of Test (SOT)					
Weight (kg)	314.8	314.7	316.4	315.0	0.545
US Backfat (BF)(mm)	2.65*a*	2.51*ab*	2.10*b*	2.47*ab*	0.147
Midpoint					
Weight (kg)	487.1*a*	472.9*b*	470.5*b*	476.0*b*	3.495
US Backfat (BF)(mm)	5.23*a*	4.39*b*	4.27*b*	4.53*b*	0.184
End of Test (EOT)					
Weight (kg)	614.7	613.8	632.2	622.3	5.450
US Backfat (BF)(mm)	8.69*a*	7.83*b*	8.09*b*	7.89*b*	0.206
SOT – Midpoint					
Average Daily Gain (kg d^{-1})	1.76*a*	1.61*b*	1.58*b*	1.64*b*	0.038
BF Average Daily Gain (mm d^{-1})	0.028*a*	0.021*b*	0.024*ab*	0.023*ab*	0.002
Dry Matter Intake (kg d^{-1})	8.41*a*	8.08*ab*	7.76*b*	7.76*b*	0.124
Days on Feed	98.0	98.0	98.0	98.0	0.000
Feed Conversion	4.78	5.03	4.94	4.73	0.126
Midpoint – EOT					
Average Daily Gain (kg d^{-1})	1.59*ab*	1.45b*c*	1.73*a*	1.36*c*	0.051
BF Average Daily Gain (mm d^{-1})	0.052*a*	0.043*ab*	0.047*ab*	0.038*b*	0.003
Dry Matter Intake (kg d^{-1})	10.63*ab*	9.98b*c*	11.22*a*	9.34*c*	0.243
Days on Feed	80.6*b*	101.7*a*	95.7*a*	113.3*a*	4.963
Feed Conversion	6.67	6.95	6.48	6.99	0.239
SOT – EOT					
Average Daily Gain (kg d^{-1})	1.70*a*	1.53*b*	1.64*a*	1.49*b*	0.035
BF Average Daily Gain (mm d^{-1})	0.035*a*	0.029*bc*	0.033*ab*	0.027*c*	0.001
Dry Matter Intake (kg d^{-1})	9.62*a*	9.24*ab*	9.74*a*	8.73*b*	0.173
Days on Feed	178.6*b*	199.7*a*	193.7*a*	211.3*a*	4.963
Feed Conversion	5.67	6.07	5.94	5.91	0.162

[v]Adlib intake over whole trial
[w]95% of adlib intake over whole trial
[x]90% of adlib intake and then to adlib intake at midpoint of trial
[y]90% of adlib intake over whole trial
[z]Standard error of the mean
a,b,c Least squares means within main effects and row with different letters differ ($P<0.05$)

Table 7. Effects of restricted feeding on carcass traits of feedlot steers

	Diet				
	1[v]	2[w]	3[x]	4[y]	SEM[z]
Shrunk Ship Weight (kg)	614.6	614.6	632.2	622.3	5.610
Carcass Weight (kg)	364.9	361.2	373.6	369.4	3.715
Dressing Percent (%)	59.5	58.9	59.2	59.5	0.247
Average Fat (mm)	7.99	7.39	7.82	7.94	0.210
Grade Fat (mm)	7.14	6.23	6.69	6.85	0.230
Ribeye Area (cm^2)	94.51	93.94	95.99	94.65	0.996
Marbling Score	2.53	2.37	2.50	2.49	0.077
Yield (%)	60.96	61.60	61.27	61.12	0.235

[v]Adlib intake over whole trial
[w]95% of adlib intake over whole trial
[x]90% of adlib intake and then to adlib intake at midpoint of trial
[y]90% of adlib intake over whole trial
[z]Standard error of the mean

Study 4: The Effects of Limit Feeding a High Energy Finishing Diet to Backgrounding Cattle in Western Canada

Rational:

Limit feeding programs have been used successfully in the United States to reduce feeding costs through improved efficiency of gain. In essence, the cattle gain the same, while feed intake is reduced 5 to 10%. Acidosis related problems are also reduced. A 10% improvement in the efficiency of Saskatchewan feedlots would make them more competitive with their Alberta and American counterparts. Limit feeding high grain diets to backgrounded cattle holds particular interest for feeders when grain prices are low relative to forage prices. One additional benefit of limit feeding high grain diets to growing cattle is that there is potential to reduce the amount of manure that is produced by the cattle thus leading to overall lower costs of production. Little information is available on limit feeding high energy diets to growing cattle under western Canadian conditions, particularly how they impact health, performance and cost of gain.

Objective:

To study the effects of limit feeding during the backgrounding period a high energy finishing diet on cattle performance under western Canadian feeding conditions.

Protocol:

In conjunction with Pound-Maker Agventures Ltd., of Lanigan, Saskatchewan, 416 crossbred steer calves weighing 290 kg were placed on feed at the University of Saskatchewan Beef Cattle Research Unit in the late fall of 2001. The cattle were assigned to 12 pens with 35 head per pen. The objective of the feeding program was to background or grow out the cattle at 1.15 to 1.25 kg per day. The 12 pens were divided equally between two treatments. These included ad libitum intake of a forage-based growing diet formulated to 3.0 Mcal DE per kg DM or 68% TDN. The second treatment was limit feeding a high energy barley grain-based finishing diet formulated to 3.4 Mcal of DE per kg of DM or 78% TDN. Limit feeding to a defined target weight was accomplished using the NRC intake equations for cattle of specific weights. The cattle were backgrounder for 77 days at which point they were transferred to Pound-Maker Agventures for subsequent finishing. Data collection included biweekly pen intakes and individual average daily gains as well as ultrasound measurements of backfat level at the start and at the end of the trial. Each animal was weighed twice at the start and end of test and once every 2 weeks throughout the trial.

Design:

The data from the backgrounding trial was analyzed as a completely randomized design with 6 pens per treatment. The pen served as the unit of comparison.

Results:

The results from this trial are presented in Tables 8 through 10 with ration composition and analysis given in Table 8. The forage based backgrounding diet was based on barley silage (24%), grass hay (27%) and a barley grain/supplement mix (49%) (DM basis) and was formulated to 3.0 Mcal DE kg DM. The high-energy limit fed diet was comprised of 91.5% barley grain and supplement and 8.5 % barley silage (DM basis). Crude protein, calcium and phosphorus levels were adjusted to ensure equal intakes across diets.

Backgrounding performance of the two groups of cattle is given in Table 9. Start of test weights averaged 290 kg with cattle carrying 2 mm of backfat. During the trial the cattle gained 100 kg of body weight at 1.3 to 1.36 kg per day with no differences between treatments. Dry matter intake of the full fed cattle averaged 8.63 kg per day with the limit fed cattle consuming 7.38 kg or 14.5% less. As a result feed efficiency was 16.4% superior for the limit fed cattle.

The superior feed efficiency of limit fed cattle translated into improved feed costs per kg of gain ($0.724 vs. 0.801) for these animals. This ultimately resulted in a savings of $8.05 per head over the 77 day feeding period (Table 10).

These results if repeatable, are of great interest to cattle feeders in western Canada. Not only does the practice of limit feeding high energy diets to growing cattle offer the potential to reduce the cost of gain, it should also lead to a reduction in manure output by the animal and thus lead to lower pen cleaning costs. This cost is one of the largest operating expenses for feedlots in Saskatchewan. Pound-Maker Agventures has on a limited basis implemented the results of this project in their backgrounding program.

Table 8. Ingredient make-up and chemical composition of backgrounding diets.

Item	Diet	
	Forage	Grain
Total mixed diet, % DM basis		
Barley silage	23.64	8.52
Hay	27.06	0.00
Concentrate	11.21	9.09
Barley grain	38.09	82.38
Concentrate, % DM basis		
Barley grain	38.22	16.81
Tallow	7.17	7.03
Canola Meal	34.30	43.24
Urea	0.00	7.26
Limestone	5.56	12.00
1:1 mineral	0.0	5.45
Rum premix	3.43	3.84
TM salt	4.45	0.0
White salt	0.0	4.36
LS 106	6.86	0.0
Chemical composition (DM basis)		
Digestible energy, Mcal/kg	3.0	3.4
Crude protein, %	13.3	16.0
Calcium, %	0.62	0.64
Phosphorus, %	0.34	0.45

Table 9. Main effects of diet on backgrounding performance of steers.

Parameter	Diet		Standard Error
	Forage	Grain	
DM Intake (kg/day)	8.63[b]	7.38[c]	0.04
Number of head	207	209	-
Days on feed	77	77	-
Weight			
Initial (kg)	290.3	290.0	0.3
End of backgrounding (kg)	392.5	394.6	1.5
ADG (kg)	1.33	1.36	0.02
Total weight gain (kg)	21 564	21 115	-
Feed:gain	6.51[b]	5.44[c]	0.06
Backfat[a]			
Initial (mm)	2.03	2.09	0.13
End of backgrounding (mm)	3.52	3.81	0.14
ADG (mm)	0.020	0.022	0.001

[a]Measured with ultrasound between 12th and 13th ribs.

[b,c]Means within the same row with different superscripts are significantly different ($p<0.05$).

Table 10. Main effects of diet on feed economic parameters of backgrounded steers.

Parameter	Diet		Standard Error
	Forage	Grain	
Feed:gain	6.51[a]	5.44[b]	0.06
Feed cost of gain ($/kg)	0.801[a]	0.724[b]	<0.01
Total feed cost ($)	16285	15178	-
Total feed savings ($/hd)	-	8.05	-

[a,b]Means within the same row with different superscripts are significantly different ($p<0.05$).

Trial 5: The Effects of Limit Feeding High Energy Finishing Diets During the Backgrounding Phase on Finishing Performance

Introduction:

An alternative to backgrounding cattle and growing them out before putting them on a full-fed finishing ration is direct finishing. In such a regimen, cattle are placed directly on a finishing ration until they go to slaughter. Limit feeding studies have been carried out with finishing cattle where intake of the finishing diet has been restricted to varying degrees relative to full fed cattle. The intent of restricting intake is that the feed efficiency of cattle improves when intake is limited (Hicks et al. 1989). Several studies have shown a 5% increase in feed efficiency when feed intake is controlled (Plegge et al. 1985, Plegge et al. 1986, Hicks et al. 1987). An improved feed efficiency in combination with decreased intake leads to lower feed costs as well as decreased manure output. This reduction in manure output can greatly decrease a producer's overall cost of production (Driedger and Loerch 1999). However, Hicks et al. (1989) found that limit feeding adversely affected carcass quality by decreasing the percentage of animals grading choice (50 vs. 100%), decreased the dressing percentage (59.6 vs. 63.1%) and also reduced carcass weight (737 vs. 773 lbs.) when compared to ad libitum feeding of the same high energy diet. No data was collected on liver abscesses, but Stock and Britton (1992) postulate that limit feeding a high grain diet causes cattle to be more hungry and therefore gorge when feed arrives, thus potentially leading to more liver abscesses.

Little research has been done in Canada on limit feeding throughout the feeding period, particularly with respect to the effects on carcass quality.

Objectives:

The objectives are to compare feedlot performance and carcass quality characteristics of cattle that have been limit fed a high grain diet either for the backgrounding period or the entire feeding period under Western Canadian feeding conditions.

Materials and Methods:

Two hundred and eighty-eight head of Charolais-cross steers weighing 338 $\pm$2.4 kg were placed on feed in the late fall of 2000. The cattle were randomly assigned to 24 pens with 12 head per pen. The pens were randomly divided into four treatments, two backgrounding and two direct finishing. The two backgrounding treatments were as follows: 1) Ad libitum intake of a high forage diet (24% barley silage, 27% grass hay and 49% barley-based concentrate / supplement, on a dry matter basis) formulated to 1.57 Mcal NE_M and 0.97 Mcal NE_G per kg dry matter (68% TDN), and 2) Limit feeding a high grain barley-based finishing diet (8.5% barley silage, 91.5% barley-based concentrate/supplement, on a dry matter basis) formulated to 1.94 Mcal NE_M and 1.27 Mcal NE_G per kg dry matter (78% TDN). The objective was to grow these cattle at a rate of 1.15 to 1.25 kg per day. Intakes were determined by NRC equations (NRC 1984) for cattle of specific weights to grow at the desired rate. The result was that during the

backgrounding period the ad lib cattle had a dry matter intake of 2.5% of their body weight, and the limit fed cattle had a dry matter intake of 2.0% of their body weight. These cattle were backgrounded for 59 days, after which they were fed ad libitum intake of a finishing diet until slaughter. The two direct finishing treatments were as follows: 1) Ad libitum intake of a finishing diet (12.1% barley silage, 87.9% barley-based concentrate/supplement, on a dry matter basis) formulated to 1.89 Mcal NE_M and 1.25 Mcal NE_G per kg dry matter (78% TDN), and 2) 93% of ad libitum intake of a finishing diet (12.1% barley silage, 87.9% barley-based concentrate/supplement, on a dry matter basis) formulated to 1.89 Mcal NE_M and 1.25 Mcal NE_G per kg dry matter (78% TDN). Ad libitum intake was determined by the 6 pens on ad libitum intake of the finishing diet; crude protein, calcium and phosphorus levels were adjusted to be equal over all diets. These direct finished cattle remained on finishing diets at their specified levels (ad libitum and 93% of ad libitum) throughout the feeding period until they went to slaughter.

Data collection included bimonthly pen intakes and individual average daily gains, as well as ultrasound measurements of backfat and ribeye area at the start of the trial, then once every 3 weeks until the final measurement before the animals went to slaughter. Each animal was weighed twice at the start of the test, once every two weeks throughout the feeding period until they were finally weighed twice just prior to slaughter. Data collection for each animal included feedlot finishing performance, carcass data and liver abscess data.

Results:

The results of this trial are presented in Tables 11 through 14.

Performance of the four groups of cattle is shown in tables 11 and 12. The cattle weighed an average of 338 $\pm$2.4 kg and carried an average of 2.8 $\pm$0.2 mm of backfat at the start of the test. During the first 59 days, the backgrounded cattle gained 80 kg of weight at a rate of 1.42 to 1.45 kg ADG, with no significant differences between treatments (Table 13). During that same period, the direct finished cattle had an average daily gain from 1.50 to 1.57 kg per day. The DMI of the backgrounded limit fed high grain cattle was almost 1 kg a day less than the full fed high forage cattle, and subsequently the feed conversion was more efficient during the backgrounding period ($P<0.05$) for the high grain limit fed cattle (5.70 vs. 6.56 for the high forage full fed cattle). The direct finished cattle had DMI from 8.50 to 8.76 kg per day, but feed conversion was comparable to that of the backgrounded limit fed high grain cattle during the first 59 days of the trial. During the finishing period, the cattle gained 210 kg of weight, but the gain was superior for the backgrounded high grain limit fed cattle ($P<0.05$). The backgrounded high grain cattle and the ad libitum direct finished cattle took less time to finish than the 93% of ad libitum direct finished cattle (114.5 and 118.6 days on feed vs. 126.9 days on feed) ($P<0.05$). The cattle backgrounded on high forage were intermediate in this respect. Overall, the high grain limit fed cattle had the highest average daily gain (1.71 kg per day) ($P<0.05$), the fewest days on feed (170.5) ($P<0.05$) and an efficient feed conversion (5.87) that was slightly poorer than that of the 93% ad libitum cattle (5.82) but not statistically different. Carcass traits were similar for all

diets (as shown in Table 14), but the direct finished cattle fed 93% of ad libitum had a notably higher percentage of liver abscesses (36.6%), although it was not statistically significant.

The results of this trial do not show positive implications of limit feeding cattle throughout the feeding period; therefore, no further repetition of this trial was planned.

Table 11. Ingredient make-up and chemical composition of backgrounding diets.

	Diet			
Item	1[v]	2[w]	3[x]	4[y]
Total mixed diet, % DM basis				
Barley silage	23.6	12.1	12.1	8.5
Hay	27.1	0.0	0.0	0.0
Concentrate	11.2	9.6	9.6	9.1
Barley grain	38.1	78.3	78.3	82.4
Concentrate, % DM basis				
Barley grain	38.2	29.1	49.5	16.8
Tallow	7.2	7.1	7.1	7.0
Canola Meal	34.3	33.9	14.6	43.2
Urea	0.0	0.0	0.0	7.3
Limestone	5.6	14.3	13.2	12.0
1:1 mineral	0.0	0.0	0.0	5.5
Rum premix	3.4	3.9	3.9	3.8
TM salt	4.5	5.0	5.0	0.0
White salt	0.0	0.0	0.0	4.4
LS 106	6.9	6.8	6.8	0.0
Chemical composition (DM basis)				
Digestible energy, Mcal/kg	3.0	3.5	3.5	3.5
Crude protein, %	13.3	14.0	13.1	16.0
Calcium, %	0.6	0.7	0.6	0.6
Phosphorus, %	0.3	0.4	0.4	0.5

[v] Ad lib intake of a high forage diet from SOT-Midpoint; ad lib intake of a high grain finishing diet after midpoint.

[w] 93% of Diet 3 (i.e. 93% of ad lib of a high grain finishing diet from SOT – EOT).

[x] Ad lib intake of a high grain finishing diet from SOT – EOT.

[y] Limited intake of a high grain diet from SOT – Midpoint; ad lib intake of a high grain finishing diet from midpoint to EOT.

Table 12. Ingredient make-up and chemical composition of finishing diets.

	Diet			
Item	1[v]	2[w]	3[x]	4[y]
Total mixed diet, % DM basis				
Barley silage	12.1	12.1	12.1	12.1
Hay	0.0	0.0	0.0	0.0
Concentrate	9.6	9.6	9.6	9.6
Barley grain	78.3	78.3	78.3	78.3
Concentrate, % DM basis				
Barley grain	49.5	29.1	49.5	49.5
Tallow	7.1	7.1	7.1	7.1
Canola Meal	14.6	33.9	14.6	14.6
Urea	0.0	0.0	0.0	0.0
Limestone	13.2	14.3	13.2	13.2
1:1 mineral	0.0	0.0	0.0	0.0
Rum premix	3.9	3.9	3.9	3.9
TM salt	5.0	5.0	5.0	5.0
White salt	0.0	0.0	0.0	0.0
LS 106	6.8	6.8	6.8	6.8
Chemical composition (DM basis)				
Digestible energy, Mcal/kg	3.5	3.5	3.5	3.5
Crude protein, %	13.1	14.0	13.1	13.1
Calcium, %	0.6	0.7	0.6	0.6
Phosphorus, %	0.4	0.4	0.4	0.4

[v] Ad lib intake of a high forage diet from SOT-Midpoint; ad lib intake of a high grain finishing diet after midpoint.

[w] 93% of Diet 3 (i.e. 93% of ad lib of a high grain finishing diet from SOT – EOT).

[x] Ad lib intake of a high grain finishing diet from SOT – EOT.

[y] Limited intake of a high grain diet from SOT – Midpoint; ad lib intake of a high grain finishing diet from midpoint to EOT.

Table 13. Effects of restricted feeding on growth traits of feedlot steers.

	Diet				
	1[v]	2[w]	3[x]	4[y]	SEM[z]
Start of Test (SOT)					
Weight (kg)	337.9	336.5	340.4	338.2	2.401
Ultrasound Backfat (mm)	2.71	2.65	2.69	3.11	0.192
Midpoint – Day 1- Day 59					
Weight (kg)	417.5	420.3	428.3	419.5	2.839
Ultrasound Backfat (mm)	3.4	3.7	3.8	3.5	0.154
End of Test (EOT)					
Weight (kg)	627.7	628.7	630.0	628.6	4.013
Ultrasound Backfat (mm)	8.18	7.40	8.09	8.19	0.192
SOT – Midpoint					
Average Daily Gain (kg/d)	1.42[b]	1.50[ab]	1.57[a]	1.45[b]	0.026
Backfat Average Daily Gain (mm/d)	0.015[ab]	0.027[a]	0.027[a]	0.009[b]	0.003
Dry Matter Intake (kg/d)	9.30[a]	8.50[bc]	8.76[b]	8.22[c]	0.062
Days on Feed	59	59	59	59	0.000
Feed Conversion	6.56[a]	5.68[b]	5.58[b]	5.70[b]	0.048
Midpoint – EOT					
Average Daily Gain (kg/d)	1.76[b]	1.66[b]	1.72[b]	1.84[a]	0.025
Backfat Average Daily Gain (mm/d)	0.038[a]	0.027[b]	0.035[a]	0.039[a]	0.001
Dry Matter Intake (kg/d)	10.67[a]	9.66[b]	10.41[a]	10.86[a]	0.21
Days on Feed	121.6[ab]	126.9[a]	118.6[b]	114.5[b]	2.188
Feed Conversion	4.41	4.15	4.19	4.21	0.053
SOT – EOT					
Average Daily Gain (kg/d)	1.65[ab]	1.61[b]	1.67[ab]	1.71[a]	0.023
Backfat Average Daily Gain (mm/d)	0.032	0.027	0.033	0.031	0.001
Dry Matter Intake (kg/d)	10.25[a]	9.33[b]	9.94[a]	10.04[a]	0.038
Days on Feed	177.64[ab]	182.93[a]	174.57[b]	170.54[b]	2.188
Feed Conversion	6.25[a]	5.82[b]	5.96[ab]	5.87[b]	0.068

[v] Ad lib intake of a high forage diet from SOT-Midpoint; ad lib intake of a high grain finishing diet after midpoint.

[w] 93% of Diet 3 (i.e. 93% of ad lib of a high grain finishing diet from SOT – EOT).

[x] Ad lib intake of a high grain finishing diet from SOT – EOT.

[y] Limited intake of a high grain diet from SOT – Midpoint; ad lib intake of a high grain finishing diet from midpoint to EOT.

[z] Standard Error of the mean.

[a,b,c] Means within the same row with different superscripts are significantly different ($p<0.05$).

Table 14. Effects of restricted feeding on carcass traits of feedlot steers.

	Diet				
	1	2	3	4	SEM
Shrunk Ship Weight (kg)	647.1	648.2	649.5	648	4.138
Carcass Weight (kg)	378.8	380.1	381.0	379.2	2.529
Dressing Percentage (%)	60.4	60.3	60.5	60.4	0.157
Average Fat (mm)	7.80	7.37	7.98	8.05	0.223
Grade Fat (mm)	6.94	6.32	6.90	7.04	0.176
Ribeye Area (cm)	99.78	102.9	100.6	100.0	1.066
Marbling Score	2.51	2.40	2.62	2.58	0.059
Yield (%)	61.8[b]	62.6[a]	62.0[ab]	61.8[b]	0.161
Liver Abscesses (%)	27.8	36.6	24.4	25.3	2.911

[v] Ad lib intake of a high forage diet from SOT-Midpoint; ad lib intake of a high grain finishing diet after midpoint.

[w] 93% of Diet 3 (i.e. 93% of ad lib of a high grain finishing diet from SOT – EOT).

[x] Ad lib intake of a high grain finishing diet from SOT – EOT.

[y] Limited intake of a high grain diet from SOT – Midpoint; ad lib intake of a high grain finishing diet from midpoint to EOT.

[z] Standard Error of the mean.

[a,b] Means within the same row with different superscripts are significantly different ($p<0.05$).

Study 6: Limit-Feeding High Energy Barley-Based Diets to Backgrounding Cattle in Western Canada

Introduction:

Limit feeding programs have been used successfully in the United States and more recently in Canada (McKinnon and Gould 2001) to improve feed efficiency and thereby reduce feed costs. On such a program, the cattle gain the same but their feed intake is reduced by 5 to 10% (Hicks et al. 1990, Loerch 1990). Additionally, acidosis related problems are reduced. A 10% improvement in efficiency of Saskatchewan feedlots would make them more competitive with Alberta and American feedlots. Limit feeding high grain diets to backgrounded cattle is particularly economical when grain prices are low in comparison to forage prices. Furthermore, limit feeding high grain diets to growing cattle has the potential to reduce the amount of manure produced (Driedger and Loerch 1999). This decreases the feeder's overall production costs, which would make Saskatchewan feedlots even more competitive. Limit feeding high energy diets to growing cattle has been studied in the United States; however, there is little information on how such a feeding program impacts health, performance and cost of gain in western Canada.

Objectives:

The current work was conducted over the fall/ winter of 2001/2002. The objective was to study the effects of limit feeding a high energy diet in the backgrounding phase on cattle performance under western Canadian feeding conditions. In particular, the intent was to determine if the results obtained in Trial 4 (i.e. a 16.5% improvement in feed efficiency and an $8 per head reduction in feed costs) over the course of the winter of 2000/2001 were repeatable.

Two trials were run simultaneously at the University of Saskatchewan research feedlot in the late fall of 2001.

Study 6a:

Materials and Methods:

In the first trial, which was conducted in cooperation with Pound-Maker Agventures Ltd., 447 crossbred steer calves weighing 269±20 kg were put on feed in the late fall of 2001. The cattle were assigned to 12 pens with 37 head in each of nine pens and 38 head in each of three pens. The objective of this feeding program was to grow the cattle at 1.15 to 1.25 kg per day. The 12 pens were divided equally between two treatments. These included ad libitum intake of a high forage diet (23.6% barley silage; 19.4% grass hay; 8.4% barley straw; 48.6% barley-based concentrate / supplement, DM basis) formulated to 1.54 Mcal NE_M and 0.94 Mcal NE_G per kg of DM (67.0% TDN). The second treatment was limit feeding a high energy barley-based finishing diet (8.5% barley silage; 91.5% barley-based concentrate/supplement, DM basis) formulated to 1.87 Mcal NE_M and 1.23 Mcal NE_G per kg of DM (77.9% TDN). Crude protein, calcium and

phosphorus levels were adjusted to ensure equal intakes in both diets. Limit feeding to a defined target weight was accomplished using the NRC intake equations for cattle of specific weights.

The cattle were backgrounded for 90 days, after which they were returned to Pound-Maker for finishing. Data collection consisted of bimonthly pen intakes and individual average daily gains as well as ultrasound backfat measurements at the beginning and at the end of the trial. Each animal was weighed twice at the start and end of the trial, and once every two weeks throughout the trial. During the finishing period, the two groups were kept separate at Pound-Maker Agventures. All livers were scored for liver abscesses (following the Elanco scoring system) at the time of slaughter at XL Beef, Moose Jaw, SK. Feedlot finishing performance and carcass data was collected for each animal.

Results:

The results from this trial are presented in Tables 15 through 17. Diet composition is given in Table 15. Backgrounding performance of the two groups of cattle is shown in Table 16. The cattle weighed an average of 269±20 kg and carried 1.5 mm of backfat at the start of the trial. Throughout the trial, the full fed high forage cattle gained an average of 112 kg at a rate of 1.24 kg per day, and carried 3.0 mm of backfat. The limit fed high grain cattle gained an average of 119 kg at a rate of 1.32 kg per day, and carried 3.8 mm of backfat. The full fed high forage cattle had an average dry matter intake of 7.11 kg per day, while the limit fed high grain cattle averaged 6.29 kg (11.5 % less). Feed efficiency was 17.2 % improved for the limit fed cattle. This result is almost identical to the improvement seen in similar fed cattle in Trial 4 conducted a year previous. Under the feed price structure for the time the trial was carried out, this superior feed efficiency in the limit fed cattle meant that feed costs per kg were improved ($0.844 versus $0.798) for these animals. Ultimately, the limit fed cattle had a savings of $5.32 per head over the 90 day feeding period (Table 17).

Table 15. Ingredient make-up and chemical composition of backgrounding diets.

Item	Forage	Grain
Total mixed diet, DM basis		
Barley silage	23.6	8.5
Hay	19.4	0.0
Straw	8.4	0.0
Concentrate	11.2	9.1
Barley grain	37.4	82.4
Concentrate, DM basis		
Barley grain	15.7	12.0
Tallow	3.5	3.5
Molasses	3.6	3.5
Canola Meal	57.3	47.0
Urea	0.0	8.3
Limestone	5.6	12.0
1:1 mineral	0.0	5.5
Rum premix	2.9	3.8
TM salt	4.5	0.0
White salt	0.0	4.4
LS 106	6.9	0.0
Chemical composition, DM basis		
Digestible energy, Mcal/kg	3.0	3.5
Crude protein, %	14.6	17.4
Calcium	0.63	0.67
Phosphorus	0.33	0.46
TDN, %	67.0	77.9

Table 16. Backgrounding parameters of cattle limit fed a high grain diet vs. cattle full fed a high forage diet.

	Diet		
Parameter	High Forage	High Grain	SEM[x]
Weight, kg			
Start of test	268.8	269.2	1.33
End of test	381.1[c]	388.1[b]	1.90
Number of head	221	223	
Days on feed	90	90	
Backfat[a], mm			
Start of test	1.51	1.56	0.08
End of test	2.97[c]	3.80[b]	0.11
Backfat ADG	0.015[c]	0.023[b]	0.001
ADG, kg/day	1.24	1.32	0.02
DMI, kg/day	7.11[b]	6.29[c]	0.02
Feed Conversion	5.75[b]	4.76[c]	0.13

[a] Measured with Ultrasound between 12th and 13th ribs.
[b,c] Means within the same row with different superscripts are significantly different ($p<0.05$).
[x] Standard Error of the Mean.

Table 17. Main effects of diet on feed economic parameters of backgrounded steers.

	Diet		
Parameter	Forage	Grain	SEM[x]
Feed: gain	5.75[b]	4.76[c]	0.13
Feed cost of gain ($/kg)	0.844	0.798	0.009
Feed cost of gain ($/lb)	0.383	0.362	0.009
Total feed savings ($/hd)		5.32	

[b,c] Means within the same row with different superscripts are significantly different ($p<0.05$).
[x] Standard Error of the Mean

Study 6b:

Materials and Methods:

In the second trial, two hundred and sixty Charolais-cross steers weighing 290.6±18.3 kg were put on feed in the University of Saskatchewan feedlot in the late fall of 2001. The cattle were assigned to 20 pens with 13 head in each pen. The objective of this feeding program was to grow the cattle at 1.15 to 1.25 kg ADG. The 20 pens were divided equally between two treatments. These treatments included ad libitum intake of a high forage diet (23.3% barley silage; 17.1% grass hay; 12.4% barley straw; 47.3% barley-based concentrate/supplement, all on a DM basis) formulated to 1.51 Mcal NE_M and 0.91 Mcal NE_G per kg of DM (66.2% TDN). The second treatment was limit feeding a high energy barley-based diet (8.5% barley silage; 91.5% barley-based concentrate/supplement, both on a DM basis) formulated to 1.87 Mcal NEm and 1.23 Mcal NEg per kg of DM (77.9% TDN). As with Trial 6a, crude protein, calcium and phosphorus levels were adjusted to ensure equal intakes over both diets. NRC intake equations were utilized to limit feed cattle to a defined target weight.

The cattle were backgrounded for 90 days, then put on finishing diets and taken off this trial. Data collection included bimonthly pen intakes and individual average daily gains as well as ultrasound backfat and ribeye area measurements at the beginning of the trial and every three weeks throughout until completion of the trial.

Results:

Results from this trial are presented in Tables 18 through 20, with diet composition given in Table 18. Backgrounding performance of the two groups of cattle is shown in Table 19. The cattle weighed an average of 290.6±18.3 kg and carried 1.3mm of backfat at the start of the trial. Throughout the trial, the full fed high forage cattle gained an average of 117 kg at a rate of 1.27 kg per day, and carried 1.9 mm of backfat at the end of the trial. The limit fed high grain cattle gained an average of 120 kg at a rate of 1.31 kg per day and carried 2.3 mm of backfat at the end of the trial. The full fed high forage cattle had an average dry matter intake of 7.93 kg per day, while the limit fed high grain cattle averaged 6.45 kg (18.7% less). Feed efficiency was improved by 21.2% in the limit fed high grain cattle versus the full fed high forage cattle. The degree of improvement in feed efficiency observed with limit feeding in this trial is the largest to date and indicates that this method of feeding can result in more efficient backgrounding gains. The greater feed efficiency in the limit fed high grain cattle meant that feed costs per kg were improved ($0.913 versus $0.827) for these animals. The limit fed cattle showed a feed savings of $10.2 per head over the 90 day feeding period (Table 20).

Further implications:

The results of these two trials as well as that of Trial 4, show clearly that limit feeding a high grain diet to backgrounding cattle will improve the efficiency of gain of the cattle. In the 3 trials conducted this improvement ranged from 16.5 to 21.5%. Feed savings which will be directly dependant on the relative price of grain to forage ranged from $ 5 to $10 per head. Such savings would be even greater when grain prices are low relative to forages. The results of trial 6 also show that the limit feeding benefits are repeatable and improves the economics of backgrounding.

Table 18. Ingredient make-up and chemical composition of backgrounding diets.

Item	Diet	
	Forage	Grain
Total mixed diet, DM basis		
Barley silage	23.3	8.5
Hay	17.1	0.0
Straw	12.4	0.0
Concentrate	11.1	9.1
Barley grain	36.1	82.4
Concentrate, DM basis		
Barley grain	15.7	12.0
Tallow	3.5	3.5
Molasses	3.6	3.5
Canola Meal	57.3	47.0
Urea	0.0	8.3
Limestone	5.6	12.0
1:1 mineral	0.0	5.5
Rum premix	2.9	3.8
TM salt	4.5	0.0
White salt	0.0	4.4
LS 106	6.9	0.0
Chemical composition, DM basis		
Digestible energy, Mcal/kg	3.0	3.5
Crude protein, %	14.3	17.4
Calcium	0.62	0.67
Phosphorus	0.33	0.46
TDN, %	66.2	77.9

Table 19. Backgrounding parameters of cattle full fed a high forage diet vs. cattle limit fed a high grain diet.

	Diet		
Parameter	High Forage	High Grain	SEM[x]
Weight, kg			
Start of test	291.2	290.2	1.57
End of test	408.0	410.7	2.29
Number of head	130	130	
Days on feed	90	90	
Backfat[a], mm			
Start of test	1.38	1.24	0.068
End of test	1.88[c]	2.26[b]	0.095
Backfat ADG	0.005[c]	0.011[b]	0.001
Ribeye area, cm			
Start of test	49.88	50.13	0.517
End of test	63.64[c]	66.84[b]	0.545
Ribeye ADG	0.15[c]	0.19[b]	0.006
ADG, kg/day	1.27	1.31	0.017
DMI, kg/day	7.93[b]	6.45[c]	0.024

[a] Measured with Ultrasound between 12th and 13th ribs.
[b,c] Means within the same row with different superscripts are significantly different ($p<0.05$).
[x] Standard Error of the Mean.

Table 20. Main effects of diet on feed economic parameters of backgrounded steers.

	Diet		
Parameter	Forage	Grain	SEM[x]
Feed: gain	6.28[b]	4.95[c]	0.142
Feed cost of gain ($/kg)	0.913[b]	0.827[c]	0.017
Feed cost of gain ($/lb)	0.414[b]	0.376[c]	0.017
Total feed savings ($/hd)		10.20	

[b,c] Means within the same row with different superscripts are significantly different ($p<0.05$).
[x] Standard Error of the Mean

Study 7: Quantification of Fecal Production in Cattle Limit fed a High Grain Barley-based diet versus Cattle Full fed a High Forage diet

Introduction:

It is clear that limit feeding a high grain diet in the backgrounding phase has many positive implications on cattle performance (i.e. decreased DMI, improved feed conversion, decreased cost of gain). Other potential benefits include improved nutrient utilization and as a result decreased manure production. Driedger and Loerch (1999) saw a 15% greater dry matter digestibility and a 29% lower dry matter intake in cattle limit fed a high energy corn-based diet as compared to an ad lib high forage diet. The result was a 40% decrease in fecal dry matter output. Manure hauling if one of the largest operating costs for feedlots in Saskatchewan, so a reduction in manure is of considerable economic interest to feedlot operators. Quantification of this manure output response is important and would be of great interest to the beef industry in Saskatchewan. It is thought that nutrient utilization improves for cattle limit fed high grain diets, which would further decrease fecal output. Loerch (1990) found that dry matter digestibility improved by 36 and 11% for 30% and 20% restricted high concentrate diets, respectively, when compared to a diet high in corn silage. Loerch (1990) feels that the improvement in digestibility occurred because grain is naturally more digestible than silage; furthermore, limiting the intake reduces the passage rate, which increases residence time in the digestive tract and thereby allows more time for digestion. Hicks et al. (1990) postulated that improvements in feed efficiency are also due to reduced daily variation in feed intake for each animal. However, little research has been done in this area using barley as the energy source, and it has scarcely been done under western Canadian conditions.

Objectives:

The objectives are to quantify how limit feeding a high grain diet affects intake, nutrient digestibility and fecal output.

Materials and Methods:

Sixteen crossbred steers weighing 273$\pm$ 13 kg were individually housed in the Livestock Research Building at the University of Saskatchewan. The steers were randomly assigned to two treatment groups. Eight animals were fed ad libitum levels of a high forage diet (23.6% barley silage; 27.1% grass hay; 49.3% barley-based concentrate/supplement, all on a DM basis) formulated to 1.57 Mcal NE_M and 0.97 Mcal NE_G per kg DM (68% TDN). The remaining eight animals were limit fed a high energy barley-based finishing diet (8.5% barley silage; 91.5% barley-based concentrate/supplement, both on a DM basis) formulated to 1.94 Mcal NE_M and 1.27 Mcal NE_G per kg of DM (78% TDN). Crude protein, calcium and phosphorus levels were adjusted to ensure equal intakes in both diets. NRC intake equations were utilized to determine the maximum amount of feed allowed for each animal to target 1.22 kg ADG for both groups of cattle (NRC 1984). Chromic oxide was included as 7% of the limit fed high grain supplement and 6% of the full fed high forage supplement.

The animals were weighed individually on a weekly basis. Diets were offered twice daily in equal amounts at 08:00 and 16:00. The animals had a 14 day adaptation period to their diets and their surroundings, followed by a 7 day voluntary intake phase and then a 5 day controlled intake phase. During the controlled intake phase, each animal received their average daily intake amount from the voluntary intake phase. A 5 day collection period followed in which individual fecal grab samples of approximately 200g were collected at 09:00, 12:00 and 16:00 each day. These fecal grab samples were frozen to be later analyzed for DM, ADF, CP and NDF. Orts were collected throughout the fecal collection period to be later analyzed for chromic oxide. Chromic oxide concentration in the fecal samples will be used to determine total tract and nutrient digestibility.

The animals were then re-randomized (i.e. randomly assigned to the two groups again) and the experiment repeated for replication.

Results:

The results of this trial are given in Table 20. Dry matter intake of the cattle limit fed the high grain diet was reduced by 17.3% (6.29 vs. 7.61 kg / day, $P < 0.05$)) relative to those fed the high forage backgrounding diet. In addition to a reduction in dry matter intake, the limit fed cattle also exhibited a 3.4% ($P < 0.05$) increase in dry matter digestibility. Reduced intake of a more digestible diet translated into a reduction in manure output of 32% in favor of the limit fed cattle.

Typical manure removal costs associated with pen cleaning in commercial lots ranges from $22 to $26 per load (2 to 4 mile trip). Typically each load of manure weighs 9 to 12 tonnes (as is) and varies on amount of straw and dirt removed. If one extrapolates these numbers to a 3000 head backgrounding lot and compares manure output on limit feeding high grain programs to full feeding forage based backgrounding rations, there is a 45% reduction in manure removal costs associated with limit feeding. Assuming bedding and dirt contamination is equal between treatments this would amount to a savings of $2500 per turn of cattle or approximately $7000 per year on 2 ½ turns of cattle.

Table 21. Fecal Dry Matter Output and Apparent Dry Matter Digestibility for steers fed a High Grain vs. High Forage Diet.

Parameter	Forage	Grain	SEM[x]
Dry Matter Intake (kg / d)	7.61[a]	6.29[b]	0.1
Fecal Dry Matter Output (kg)	1.57[a]	1.07[b]	0.03
Apparent Dry Matter Digestibility (%)	79.39[b]	82.79[a]	0.43

[a,b] Means with different superscripts significantly different ($p<0.05$).
[x] Standard Error of the Mean.

Conclusions:

Two basic approaches were taken to develop limit-feeding programs for cattle fed under western Canadian conditions. The first involved limit feeding backgrounding or finishing diets at a pre-determined level relative to full fed cattle (Trials 1 and 3). The second involved programmed or limit feeding a high grain finishing diet to achieve a pre-set level of daily gain. The practical application of the results differed markedly between the two approaches. In trial 1 and 3 limit feeding backgrounding or finishing diets to levels ranging from 87 to 95 % of full fed cattle resulted in a corresponding drop in average daily gain that matched almost exactly the reduction in feed intake. As a result there was no improvement in feed efficiency and with finishing cattle the animals required a considerably longer period of time on feed to achieve the same gains. Differences between the success of such programs observed between western Canada and the United States were attributed to environmental effects and the fact that under western Canadian conditions limit feeding in such a manner reduces energy intake for maintenance requirements to keep warm and as a result animal performance suffers.

The second approach to limit feeding shows considerably more promise. That is the practice of program feeding a high energy finishing diet to specific rates of gain. In trial 4 of this series we examined the effects of limit feeding a high-energy barley-based finishing diet to backgrounding cattle targeted for 1.3 kg per day gain. The results indicated that cattle limit fed the high energy diet during the backgrounding period exhibited a similar daily gain (1.36 vs. 1.33 kg / day) to cattle fed a forage based diet ad libitum, however dry matter intake was reduced by 15%. This resulted in an improvement of 16.5 % in feed efficiency, which translated in a reduced cost of gain of $0.08 per kg of gain or $8.05 per head. Further work was under taken to determine the repeatability of these results. In trials 5 and 6, which were conducted in a similar fashion, improvements in feed efficiency ranged from 17 to 22% with feed cost savings calculated under the actual pricing conditions of the study ranging from $5 to $10 per head. In a 3000 head backgrounding lot this would translate to a savings of $15,000 to $30,000 per turn of cattle or $30,000 to $60,000 per 6000 head fed per year. It should be noted that the economic benefits of limit feeding a high grain diet will be dependant on the relative price of grain to forage sources. When grain is cheap, feed savings in excess of what was found in this trial can be expected. As forages become cheaper, then savings are reduced.

The final phase of this work focused on determining the impact that limit feeding a high grain diet to backgrounding cattle has on manure production. It was found that limit fed cattle had a 32% reduction in fecal dry matter output relative to full fed cattle fed to gain the same on a high forage diet. When these numbers are extrapolated to commercial pen cleaning costs, a 45 % reduction in manure removal costs is achieved with limit feeding.

The results of this study are of significant interest to the feeding industry in Saskatchewan and western Canada. Not only is the cost of gain reduced but limit feeding a high energy diet that has increased nutrient availability will markedly reduce manure output by the animal. Since pen cleaning is a major cost for feedlots in Saskatchewan, limit-feeding programs will significantly reduce operating costs for cattle feeders in this province.